FINAL REPORT

Grant Title: Analysis of Voyager Radio Data from Neptune

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1. Research for the following paper, which was supported by the grant, was based on our analysis of Jupiter and Neptune data from the Voyager spacecraft: "Recalibration of the Voyager PRA antenna for polarization sense measurement", by L. Wang and T. D. Carr, *Astronomy and Astrophysics* **281**, 945–954, (1994).

Abstract. The Voyager Planetary Radio Astronomy antenna and receiver system provides an indication of the sense of elliptical or circular polarization of radiation that is not correct for all directions of incidence. The true sense could be determined for all directions if accurate calibration data were available. It was not feasible to make the calibration before the Voyagers were launched. Lecacheux & Ortega-Molina (1987), however, were able to derive such calibration data from planetary radio observations made in flight. They expressed their results in terms of the tilt of a plane (the E-plane) that divides the incident ray directions for which the indicated polarization sense is correct from those directions for which the indicated sense is reversed. We demonstrate that there are certain directions for which this calibration is itself in error, and that the surface dividing the two sets of incident rays is more complex than a tilted plane. We are able to make a crude approximation to the true surface from the limited data available.

2. Dr. Liyun Wang, who has been supported by the grant as a Graduate Research Assistant in the Department of Astronomy of the University of Florida, was awarded the PhD degree in August 1994. The title of his dissertation is "Investigation of Hectometric and Kilometric Radio Emissions from Jupiter and Neptune" (Dept. of Astronomy, Univ. of Florida, 1994). Copies of this dissertation are available on request.

Abstract. This dissertation concerns radio emissions at hectometric and kilometric wave lengths from the planets Jupiter and Neptune, as observed with the Planetary Radio Astronomy (PRA) experiment on board the two Voyager spacecraft. Serious errors were found in the previously accepted calibration of the PRA antenna system for polarization sense determination, and these errors were corrected. It was concluded that the E-surface

of the antenna is not a single plane as had previously been supposed—that its tilt can be significantly different at different azimuths. New observational results of the Jovian hectometric emission (HOM) are presented. Characteristics of the HOM are discussed. It is found that the HOM emission at different frequencies is beamed into different magnetic latitudes. The beaming profile is shown to contradict the generally accepted belief that refraction of rays passing through the Io plasma torus is soley responsible for the beaming. A beaming model is established that can account for the major characteristics of the HOM observation. Raytracing (both two-dimensional and three-dimensional) was performed over the entire frequency range of HOM. It was demonstrated that although the presence of the Io plasma torus can affect HOM propagation to a limited extent, it cannot be responsible for the magnetic equatorial beaming and shadowing of the emission (as had been reported by others). A special spacecraft maneuver event was successfully used, in conjunction with raytracing, as an aid is searching for the HOM source location; the result was consistent with a source location predicted by our beaming model. Finally, the previously reported results from Voyager 2 observations of the Neptunian kilometric radiation are reviewed, followed by the presentation of greatly improved new results on its source location and beam structure at the different frequencies. [Note: The latter results were the principal basis for the important advances made in our knowledge of the Neptunian radiation that are presented in the next paper.]

3. The paper "A model for the source location and beam geometry of Neptune's principal smooth radio component", by Liyun Wang and Thomas D. Carr, has been submitted to *Journal of Geophysical Research* for publication.

Abstract. Two empirical models were developed for the location and beam structure of Neptune's RH-polarized corotating smooth-component radio source. The O8 magnetic field model was assumed. The usual assumptions were also made that (a) the source is distributed within a region such that X-mode emission toward the spacecraft would be RH elliptically polarized, (b) the resultant beam is the sum of elementary hollow-cone beam components for which the cone axes are tangent to the magnetic field at the individual source elements, and (c) all the source elements lie just above the surface on which the electron cyclotron frequency equals the frequency of the emitted radiation. (The resultant beam was found also to be confined to a hollow cone, indicating a relatively small source area.) For the more realistic of the two models, an additional requirement was imposed that all ray paths to the spacecraft must lie entirely outside this surface, i.e., within the radio horizon. At each of several frequencies between about 40 and 400 kHz, the adjustable model parameters were varied to yield calculated intensity vs time curves at the spacecraft location that most closely matched the observed intensity vs time curves. The model indicated that the source is located within or near the L=20 auroral zone surrounding the relatively weak north-magnetic pole that is largely conjugate to the dominant south-magnetic pole of the complex field of the planet. At 116 kHz, it was found that the half-angle of the hollow-cone emission was approximately 80° (at its midpoint) with a beam-wall thickness of about 15°. At higher frequencies the beam half-angle and wall thickness were somewhat less than these values. A new component of the Neptunian radio emission is also described,

which is LH-polarized, is of extremely narrow bandwidth, and is believed to be confined within an unusually thin-walled hollow-cone emission beam. It is referred to as the LNT component. Evidence is presented suggesting that it is O-mode emission from the same source that produces the X-mode smooth component.

4. No patents have resulted from the work supported by this grant.

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